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LECTURES
ON
ASTRONOMY,
AND
NATURAL PHILOSOPHY,
FOR THE
USE OF CHILDREN.

DESIGNED TO UNITE
SENTIMENTS OF RELIGION
WITH THE
STUDY OF NATURE.

In Contemplation of Created Things
By Steps we may ascend to GOD.

MILTON.

BATH, PRINTED BY R. CRUTTWELL:
AND SOLD BY
C. DILLY, POULTRY, LONDON.

1794.



PREFACE.

THE great encouragement which is given in the present age to every attempt towards forming the minds of Children, induces the author of the following Lectures to hope that their general plan may procure them a favourable reception.

T

The scientific part is not offered as a complete system. The geographical description of the earth, with the names of the artificial circles, and every thing relative to the use of the globes, is omitted;

ted; as they would only be a repetition of what has already been given to the public in *The Circle of the Sciences*, and *Turner's Geography*. Much useful information, as well as entertainment, may be derived from *Newbery's Newtonian Philosophy*, to supply the deficiencies of this little book; which is principally designed to unite sentiments of religion with the study of nature; and to give a proper direction to that spirit of curiosity inherent in the human mind, by which it is impelled, from the first dawning of reason, to rise from effects to causes, and to endeavor to trace all the objects of its observation to their original source.

Those principles and sentiments which ought to influence us through life, cannot be too early or too forcibly impressed;

prest; and if children are from infancy accustomed to connect the idea of the works of nature with that of its Great Author, they will scarcely afterwards be either able or desirous to separate them. A combination of ideas is not easily broken:

Such is the secret union, when we feel
A song, a flower, a name, at once restore
Those long-connected scenes where first they mov'd
Th' attention.†

The science of astronomy seems peculiarly calculated, by the grandeur and sublimity of its objects, to elevate and ennable the mind, and to lead the imagination through the immense chain of created being

“ Progressive to the Deity.”

* Akenside.

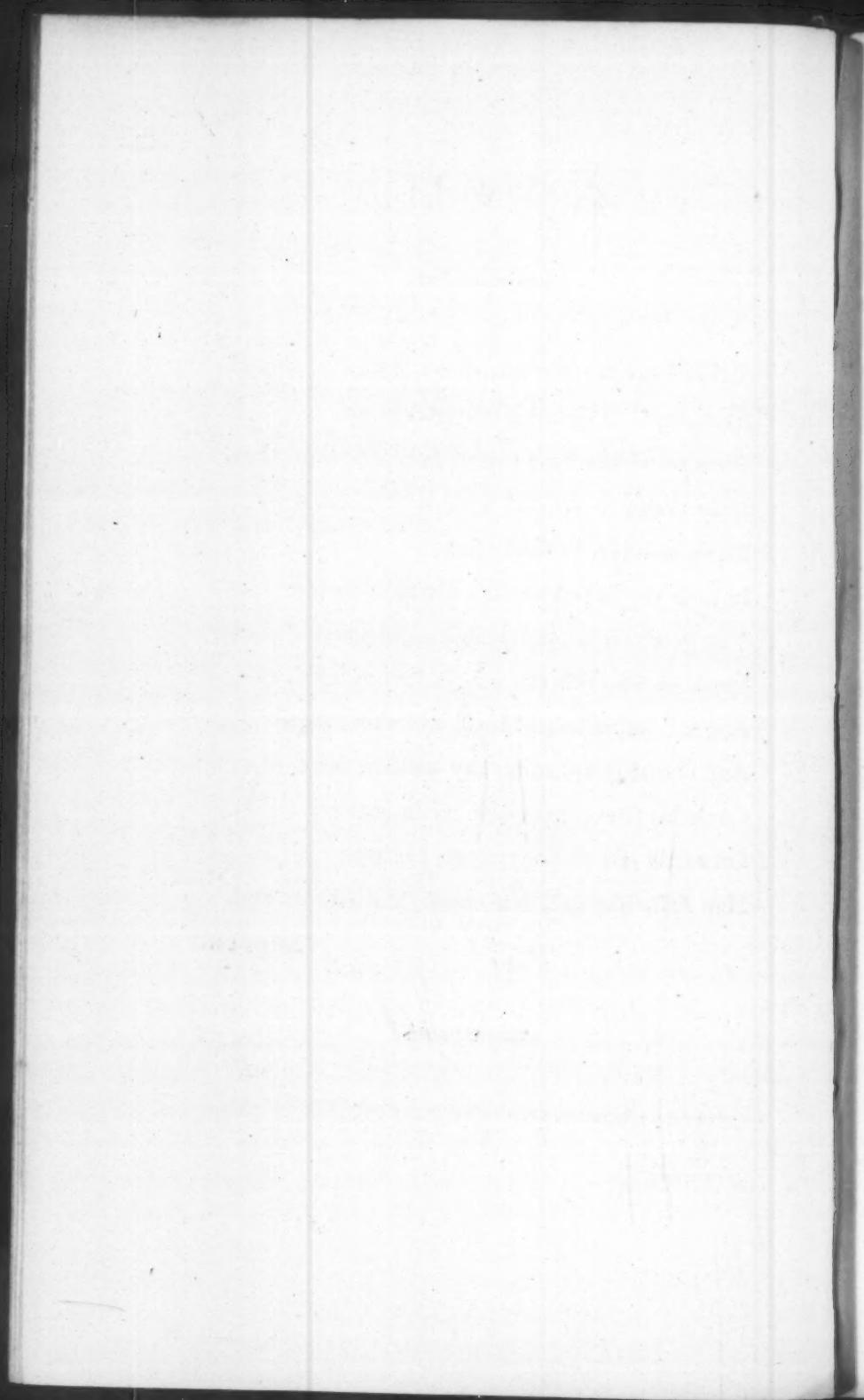
The

The quotations from the poets will not, perhaps, be generally unacceptable; and to those who may disapprove the insertion of them in a work of this kind, the Author ventures to plead the example of BONNYCASTLE in his *Introduction to Astronomy*, and of MR. AIKIN, in his *Calendar of Nature*.



THESE are thy glorious works, Parent of Good!
Almighty! Thine this universal frame,
Thus wondrous fair: thyself how wondrous then,
Unspeakable! Who fit'st above these heavens,
To us invisible, or dimly seen,
In these thy lowest works: yet these declare
Thy goodness beyond thought, and power divine.
Speak ye who best can tell, ye sons of light!
Angels! for ye behold him; and with songs,
And choral symphonies, day without night
Circle his throne rejoicing: ye in heaven:
On earth join all ye creatures to extol
Him first, him last, him midst, and without end.

MILTON.



LECTURE I.

*Of the ELEMENTS, and of the Animal,
Vegetable, and Mineral Kingdoms.*

IN the beginning God created the heaven and the earth.

And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit-tree yielding fruit; and it was so.

And God said, Let the waters bring forth abundantly the moving creature that hath life, and fowl that may fly above the earth in the open firmament of heaven; let the earth bring forth cattle, and creeping thing, and beast of the earth: and it was so.

And God said, Let us make man in our image, after our likeness.

And God saw every thing that he had made, and behold! it was very good.

He

He causeth the grass to grow for the cattle,
and herb for the service of man.

The eyes of all wait upon Thee, and Thou
givest them their meat in due season.

Thou openest thine hand, and satisfiest the de-
sire of every living thing.

O LORD! how manifold are thy works! In
wisdom hast Thou made them all: the earth is
full of thy riches.

PHILOSOPHERS generally believe the material world to be composed of four principles, or elements; viz. earth, air, fire, and water: which being blended or mixt together in various proportions, constitute the substance, of which the earth and all things within it, and upon it, are formed. The word element is therefore frequently used metaphorically to express the principles or first beginnings of any science, as the elements of grammar, of history, &c. and these lectures

Lectures may be termed *the Elements of Astronomy and Natural Philosophy*, because they are designed to give you an idea of the nature and first principles of those sciences. If in future you should be inclined to pursue these studies, you will meet with a variety of books to assist your enquiries; but while you are so young, there are several other acquirements more necessary to occupy your time and attention; and I believe this little book, with those already mentioned in the preface, will afford you all the information on these subjects which is requisite at your age.

ALL the productions of the earth are ranged under three classes or heads; which are termed the animal, vegetable, and mineral kingdoms.

The animal kingdom comprehends every creature endued with both life and sensation; viz. men, beasts, birds, fishes, insects, and reptiles, or creeping things.

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The vegetable kingdom comprises all things which have life without sensation; as trees, shrubs, flowers, grain, herbs, grass, and mosses.

The mineral kingdom includes every thing upon and within the earth, which has neither sensation nor life; as stones and metals. Minerals are also called fossils, and are classed under the three following heads: first, the petræ, or barren stony substances, as marble, &c. secondly, the mineræ, or prolific stony substances, as precious gems and metals; thirdly, the fossilia, including petrifications, which are animal or vegetable substances changed into mineral.

Ores are the metals as they are first dug out of the mines, before they have been separated from the earth and other substances with which they are originally mixt.

AIR and ye elements! the eldest' birth
 Of nature's womb, that in quaternion run
 Perpetual circle, multiform; and mix
 And nourish all things; let your ceaseless change
 Vary to our Great Maker still new.praise.

Fountains! and ye that warble as ye flow
 Melodious murmurs! warbling tune his praise.
 Join voices, all ye living souls! ye birds,
 That singing up to heaven-gate ascend,
 Bear on your wings, and in your notes, his praise.

Ye that in waters glide, and ye that walk
 The earth, and stately tread or lowly creep!
 Witness if I be silent morn or even,
 To hill or valley, fountain, or fresh shade,
 Made vocal by my song, and taught his praise.

MILTON.

SOFT roll your incense, herbs, and fruits, and
 flowers,
 In mingled clouds to Him, whose sun exalts,
 Whose breath perfumes you, and whose pencil paints.

Ye forests bend, ye harvests wave to Him:
 Breathe your still song into the reaper's heart,
 As home he goes beneath the joyous moon.

THOMPSON.

LECTURE

LECTURE II.

Of the SOLAR SYSTEM.

AND God said: Let there be lights in the firmament of the heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and years. And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: he made the stars also. And God set them in the firmament of the heaven, to give light upon the earth; and to rule over the day, and over the night; and to divide the light from the darkness; and God saw that it was good.

The heavens declare the glory of God, and the firmament sheweth his handy-work.

He appointed the moon for certain seasons; and the sun knoweth his going down.

BY

BY the SOLAR SYSTEM, is meant that portion alone of the universe, which comprehends the Sun, the Planets with their satellites, and the Comets.

Of this system the *Sun* is the centre: he remains stationary, but turns upon his own axis in about $25\frac{1}{2}$ days. There are seven planets moving round him, each in a different orbit or path. The names of these planets, according to the order of their distance from the sun, are, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and the Georgium Sidus. The two first, Mercury and Venus, are called *inferior* planets, because they move within the earth's orbit; that is, nearer to the sun. The four last are called *superior* planets, because their orbits are without that of the earth; that is, further from the sun.

The figure of the planets is that of a sphere, or globe; and they turn continually upon their own axes from west to east, as the

artificial globe turns upon the wire which passes through its poles : at the same time, by a progressive motion through their orbits from west to east, they revolve round the sun, which remains stationary in the centre. They have no light of their own, but shine by means of the borrowed light which they receive from the sun.

Mercury, the nearest planet to the sun, moves round him in rather less than three months, which consequently is the length of his year ; the year in each planet being the space of time which it occupies in going round the sun. Mercury is seldom seen, on account of his being so near to the sun as to be generally concealed by his rays ; and the time of his rotation on his axis, or the length of his days and nights, has not yet been discovered.

Venus, the next planet to Mercury, completes her annual or yearly revolution round the sun in about $7\frac{1}{2}$ months ; and her diurnal or daily rotation upon her own axis in
about

about $23\frac{1}{2}$ hours. When this planet appears to the west of the sun, she rises before him in the morning, and is called the morning star; and when she appears to the east of the sun, she shines in the evening after he sets, and is then called the evening-star; being in each situation, alternately, for about $7\frac{1}{2}$ months.

The next planet above Venus is *the Earth*, whose annual revolution is performed in 365 days, 5 hours, and 49 minutes, or rather more than 12 months; and its diurnal rotation in about 24 hours. Every fourth year, one day is added at the end of February, to recover the time which the earth spends in her annual course above the 365 days, which compose a common year. This fourth year therefore consists of 366 days, and is called bissextile, and also leap-year.

Next above the earth's orbit is that of *Mars*; who completes his revolution round the sun in somewhat less than two of our years,

years, and his rotation upon his axis in rather more than $24\frac{1}{2}$ hours.

Jupiter, the largest of all the planets, holds the next place to Mars in distance from the sun. He performs his annual revolution in rather less than 12 years, and his diurnal rotation in about 10 hours. *Jupiter*, as well as *Venus*, is sometimes called a morning, and sometimes an evening-star.

Next to the orbit of *Jupiter* is that of *Saturn*; who completes his annual revolution round the sun in about $29\frac{1}{2}$ years. The time of his diurnal rotation is unknown.

Saturn was generally considered as the remotest planet of our system, till, on the 13th of March, 1781, Dr. Herschel discovered another, still further distant from the sun, round which it revolves in an orbit nearly circular in about 82 years. To this planet Dr. Herschel has given the name of the *Georgium Sidus*.

Besides these seven, which are called primary planets, there are in our system fourteen

teen others, called secondary planets, or satellites, which regard these primaries as the centres of their motions, and move round them in the same manner as the primaries revolve round the sun.

The first of these satellites is the *Moon*; which, while she accompanies the earth in its annual progress through its orbit, is continually revolving round it; and this revolution she performs in about $29\frac{1}{2}$ days. Her distance from the earth is 24,0000 miles. As the same face of the moon is constantly towards us, it is evident that she turns only once round upon her axis in the time of each periodical revolution round the earth, so that the inhabitants of the moon, if there be any, have but one day and one night in the course of a month. When the moon is in that part of her orbit which is between the earth and the sun, she is said to be in conjunction with him: then the whole of her enlightened hemisphere is turned from the earth, and she is called a new-moon. When she has advanced

vanced through one quarter of her orbit, that part of her enlightened hemisphere which we see is in the form of a semicircle, and the moon is then said to be at her first quarter. When she has proceeded through half her orbit, the whole enlightened hemisphere is turned towards the earth: she is then in opposition to the sun, and is called a full-moon. The sun and moon are then in opposite parts of the heavens; the moon rising in the east, as the sun sets in the west. When the moon has past through three quarters of her orbit, she is said to enter into her last quarter, and again appears semicircular. When she has completed her revolution, the whole enlightened hemisphere again becomes invisible, and we have another *new-moon*. From the new to the full-moon, the enlightened part is turned towards the west, because the sun is then westward of it; but from the full to the new-moon, it is turned to the east, because the sun is then eastward of it. At the time of the full-

moon

moon which happens next before the autumnal equinox, she appears larger at her rising than usual, and rises nearly at the same hour, for several evenings together, immediately after the full: this is vulgarly called the harvest-moon. Sometimes the same happens again at the next full-moon, though not in so great a degree; and this is called by the common people the hunter's-moon. These circumstances are owing to its peculiar situation at these periods with respect to the earth; a particular explanation of which would be unintelligible, without a further knowledge of astronomy than you at present possess.

Jupiter has four satellites or moons, Saturn seven, and the Georgium Sidus two; these are all spherical bodies like the primary planets, and, like them, shine only by reflecting the light which they receive from the sun.

Saturn has, besides his seven satellites, a luminous or shining ring, which encompasses him; but at such a distance from his body, that the fixed stars may frequently be seen
between

between the inner surface of the ring and the planet itself. Dr. Herschel has lately discovered that this ring is divided into two parts, an inner and an outer ring, which are separated from each other by a space of one thousand miles.

The satellites of the planets, and Saturn's ring, are visible only by the assistance of a telescope; by means of which also, several faint parallel stripes, called belts, are discernible upon the body of Jupiter.

HAVING enumerated the planets and their attendants, the Comets are now the only bodies belonging to our system which remain to be mentioned; and of these the number is unknown. It has been found, from a variety of observations, that they move round the sun, and cross the orbits of the planets in all manner of directions. They

are

are of various magnitudes, and are solid opaque bodies, like the planets; from which they are principally distinguished in their appearance by long transparent tails, which resemble a pale flame, and issue from that side of the comet which is the furthest from the sun. The orbits in which these bodies move, are exceedingly long ovals, or ellipses, of such vast circumferences, that at one period of their course through them, they approach so near to the sun, as to be almost melted by his heat, and then go off again to distances so immense, that they must be totally deprived of both his heat and light.

Periodical Revolutions of the Planets round the Sun.		Diurnal Rotations upon their Axes.		Mean Distances from the Sun.	
		Days.	Hours. Minutes.	Hours.	Minutes. Seconds.
Signs of the Planets.					English Miles.
Mercury	-	♀	87	23	15 $\frac{1}{2}$
Venus	-	♀	224	16	49 $\frac{1}{4}$
Earth	-	⊕	365	5	49
Mars	-	♂	686	23	30 $\frac{3}{4}$
Jupiter	-	♃	4332	.8	51 $\frac{1}{2}$
Saturn	-	♄	10761	14	36 $\frac{3}{4}$
Georgium Sidus			30445	18	*

FAIREST of stars! last in the train of night,
If better thou belong not to the dawn,
Sure pledge of day, that crown'ft the smiling morn
With thy bright circlet, praise Him in thy sphere,
While day arises, that sweet hour of prime.

Thou Sun! of this great world both eye and soul,
Acknowledge Him thy greater; found his praise
In thy eternal course, both when thou climb'ft,
And when high noon hast gain'd, and when thou
fall'ft.

Moon! that now meet'ft the orient sun, now fly'ft,
With the fix'd stars, fix'd in their orb that flies;
And ye five other wand'ring fires! that move
In mystic dance, not without song, resound
His praise, who out of darkness call'd up light.

MILTON.

LECTURE

LECTURE III.

Of the FIXED STARS.

BY the word of the Lord were the heavens made; and all the host of them by the breath of his mouth. He spake, and it was done: he commanded, and it stood fast.

He telleth the number of the stars: he calleth them all by their names.

Hearken unto this: consider the wondrous works of God.

Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion? Canst thou bring forth Mazzaroth* in his season, or canst thou guide Arcturus with his sons? Dost thou know the wondrous works of him which is perfect in knowledge? which maketh Arcturus, Orion, and Pleiades: which doeth great things past finding out, yea, and wonders without number.

* Mazzaroth is supposed to signify the Zodiac.

The

THE *Fixed Stars* are distinguishable from the planets by their continual scintillation or twinkling. These stars are called fixed, because they never change their situation with regard to each other, as the planets do. For though the revolutions of the earth occasion an apparent motion of the heavens, yet, if any two fixed stars be observed at several intervals of time, they will always be found to preserve the same position with respect to each other, during the whole course of the observation.

These stars are all supposed to be suns, placed at vast distances in the immense universe; each shining by its own light; and each situated in the centre of a system, in which planets revolve round them as round our sun, but too distant from the earth to be visible to us; as their light is only borrowed from their suns, and is therefore too faint to reach so far.

The

The distance of the fixed stars from us is so great, that even the nearest of them, which is Sirius, the dog-star, never appears to vary in its dimensions to our sight, though the earth, in its annual revolution, is 195 millions of miles nearer to it when in one part of its orbit, than when in that which is opposite.

Those fixed stars which appear to us the largest, are called stars of the first magnitude; those which appear somewhat less, of the second; and so on to the sixth; and these include all which are visible without a telescope. The number which may be seen at once with the naked eye, is not more than a thousand; but those which are visible by means of a telescope, are innumerable.

The galaxy, or milky-way, is one continued cluster of stars; which combine to illuminate that part of the firmament.

The heavens are divided by astronomers into three regions, called the Northern and Southern hemispheres, and the Zodiac. The fixed

CONSTELLATIONS IN THE ZODIAC.

CONSTELLATIONS.				Signs.	ENGLISH NAMES.		PRINCIPAL STARS.	
Aries	-	-	-	♈	The Ram	-		
Taurus	-	-	-	♉	The Bull	-	Pleiades, a cluster in the neck.	Hyades, cluster in face.
Gemini	-	-	-	♊	The Twins	-	Castor and Pollux, in the head of the Twins.	Aldebaran, (the Bull's eye) [one of the Hyades.]
Cancer	-	-	-	♋	The Crab	-	Præsepe, in back.	
Leo	-	-	-	♌	The Lion	-	Regulus, or Cor Leonis, heart.	Deneb Al Affad, in tail.
Virgo	-	-	-	♍	The Virgin	-	Vindemiatrix, in right shoulder.	Spica Virginis, wheat in right hand.
Libra	-	-	-	♎	The Balance	-	Zubereschemali, in right scale.	Zuberelgenufi, in left scale.
Scorpio	-	-	-	♏	The Scorpion	-	Antares, or Cor Scorpii, heart.	Lefath, in tail.
Sagittarius	-	-	-	♐	The Archer	-	Nebulosæ, in nose.	
Capricornus	-	-	-	♑	The Goat	-	Deneb Al Gedi, in tail.	
Aquarius	-	-	-	♒	The Waterer	-	Scheat, in leg.	Fomalhaut, last in the water.
Pisces	-	-	-	♓	The Fishes	-	Nodus Celestis, the knot of the ribbon.	

These are the Signs of the Zodiac. The six first are called the Northern Signs, and the six last the Southern.

SOUTHERN CONSTELLATIONS.

CONSTELLATIONS.		ENGLISH NAMES.			PRINCIPAL STARS.	
Cetus	-	The Whale	-	-	Menhar, in mouth.	Batan Ketus, in side.
Eridanus	-	-	-	-	Deneb Ketus, in tail.	Achernar.
Phoenix						
Toucan						
Orion	-	-	-	-	Rigol, in right foot.	Bellatrix, in right shoulder.
Monoceros	-	The Unicorn	-	-	Betelgeuge, in left shoulder.	
Canis Minor	-	The Lesser Dog	-	-	Procyon, in side.	
Apus						
Hydra	-	-	-	-	Alphard, or Cor Hydræ, heart.	
Sextans Uraniae						
Crater	-	The Cup	-	-	Alches, in stand.	
Corvus	-	The Raven	-	-	Algorab, in right wing.	
Centaurus	-	The Centaur				
Lupus	-	The Wolf				
Ara	-	The Altar				
Triangulum Australis	-	The Southern Triangle				
Pavo	-	The Peacock				
Corona Australis	-	The Southern Crown				
Grus	-	The Crane				
Piscis Australis	-	The Southern Fish				
Lepus	-	The Hare				
Columba Noachi	-	Noah's Dove				
Robur Caroli	-	Charles's Oak	[fiers			
Crux	-	The Cross, sometimes Cro-				
Argo Navis	-	The Ship Argo	-		Canopus.	
Canis Major	-	The Greater Dog	-		Sirius, (the Dog-Star) in mouth.	
Apis	-	The Bee			Iasis, in right ear.	
Hirundo	-	The Swallow				
Indus	-	The Indian				
Cameleon						
Piscis Volans	-	The Flying Fish				
Xiphias	-	The Sword Fish				

NORTHERN CONSTELLATIONS.

CONSTELLATIONS.	ENGLISH NAMES.	PRINCIPAL STARS.
Ursa Major, or Helice	The Greater Bear	Dubhe, in neck. Aliath, and Benenatch, in tail. Alcor, small one in tail.
Ursa Minor	The Lesser Bear	Cynosura, (the Polar Star) in tail. Kochab, in neck.
Draco	The Dragon	Ras Tabin, in head.
Cepheus	-	Alderamin, in left shoulder.
Canes Venaticæ (Asterion, and Chara)	The Hounds	
Bootes	-	Arcturus, in coat. Ceginus, in right shoulder. Mirach, in belt.
Mons Menalus		
Coma Berenices	Berenice's Hair	
Cor Caroli	Charles's Heart	
Corona Borealis	The Northern Crown	Alphacca, or Lucida Coronæ.
Hercules, or Engonasi	-	Ras Al Giethi, in head. Rutilicum, in left shoulder. Marfic, in club. Maafym, in right arm.
Cerberus		
Lyra, or Vultur Cadens	The Lyre	Lucida Lyræ.
Cygnus	The Swan	Deneb Adigege, in tail. Agilfage,
Vulpecula	The Fox	Albirco, in beak.
Anser	The Goose	
Lacerta Stellio	The Lizard	
Cassiopeia	-	Shader, in breast.
Camelopardus	The Camelopard	
Serpens, or Ophiuchi	The Serpent	
Serpentarius, or Ophiuchus	-	Ras Al Hague, in head. Yed, in right hand.
Scutum Sobieski	Sobieski's Shield	
Aquila, or Vultur Volans	The Eagle	Alcair, or Atair, in neck.
Antinous, or Ganymedes	-	
Delphinus	The Dolphin	
Equulus	The Little Horse	
Sagitta	The Arrow	
Andromeda	-	Caput Andromedæ, in head. Migar, in belt. Almaak, in right foot.
Perseus	-	Caput Medusæ, (Medusa's Head) a cluster. Algol, in Caput Medusæ. Algenib, in side.
Pegasus	-	Enif, in nose. Marhab, in shoulder. Scheat Alpherus, in left leg.
Auriga	The Charioteer	Capella, in the Goat. Hædi, the Kids.
Lynx		
Leo Minor	The Lesser Lion	
Triangulum	The Triangle	
Triangulum Minus	The Little Triangle	
Musca	The Fly	

fixed stars were classed by the ancients under the outlines of certain imaginary figures of birds, beasts, fishes, and other animals; and these figures are called Constellations. The number of these, including those which have been added in later times, is in the Northern hemisphere 36, in the Southern 32, and in the Zodiac 12. As there are some stars which are not comprehended in any constellation, these are called unformed stars; and some, which have a cloudy appearance, are called nebulae.

Astronomers mark the stars with the letters of the Greek alphabet, denoting that which is most conspicuous in each constellation by the first letter, the next by the second, and so on; and they are thus marked upon the globe. This was an invention of John Bayer, a German, about the year 1600. Some of the principal fixed stars are distinguished by particular names.

The last star in the tail of Ursa Minor, or the Lesser Bear, is called the polar star:
and

and serves for a guide to sailors: because on account of its proximity, or nearness to the North pole, its apparent situation with regard to the earth scarcely varies throughout the entire period of the earth's annual revolution. Two of the stars in the constellation of Ursa Major, or the Greater Bear, are called the pointers, because they point to the polar star.

During part of the months of July and August, Sirius, the dog-star, rises and sets with the sun; on which account those days are called the Dog-days.

Ye that keep watch in heaven, as earth asleep
Unconscious lies, effuse your mildest beams,
Ye constellations! —————

————— The radiant orbs,
That more than deck, that animate the sky,
The life-infusing funs of other worlds.

THOMPSON.

LECTURE IV.

*Of the SEASONS, DARS and NIGHTS,
ECLIPSES, and TIDES.*

O Give thanks unto the Lord, for he is good.
To Him that made great lights: the sun to rule
by day; the moon and stars to rule by night.

The day is thine: the night also is thine: Thou
haft prepared the light and the sun.

Thou haft set all the borders of the earth:
Thou haft made summer and winter.

Thou crownest the year with thy goodness.

Who hath shut up the sea with doors, and
said, Hitherto shalt thou come, but no further;
and here shall thy proud waves be stayed?

They that go down to the sea in ships, that
do busines in great waters, these men see the
works of the Lord, and his wonders in the deep.
For at his word the stormy wind ariseth, which

lifteth up the waves thereof. Then they cry unto the Lord in their trouble, and he bringeth them out of their distresses. He maketh the storm to cease, so that the waves are still.

THE alternate succession of day and night is occasioned by the uniform rotation of the earth upon its axis; this is called its diurnal motion, and is performed in twenty-four hours; in which space of time we have one day and one night. Whilst that part of the globe which we inhabit is turned towards the sun, we have day; and when it is turned from it, we have night. You may easily understand this, by marking a ball with spots to denote the different quarters of the globe, and then holding it near a candle: one half will be light, and the other dark: when one spot is in the light half, the opposite one will be in the dark half; and thus whilst it is day in

in England, it is night in some parts of America. If you turn the ball round, it will give you an idea of the motion of the earth, and of the manner in which each part is successively illuminated. As the earth turns from west to east, the celestial bodies appear to move from east to west; and therefore the sun rises in the east, and sets in the west.

THE VARIATION of the SEASONS (or the vicissitudes of spring, summer, autumn, and winter) is caused by the earth's annual motion round the sun not being in the plane of the equator, but in an orbit inclined to it in an angle of twenty-three degrees and a half.

A *Solar Eclipse*, or an eclipse of the sun, is occasioned by the moon's passing between the earth and the sun, and thereby hiding the

light of the sun from the earth; which can only happen when the moon is in conjunction with the sun; that is, at the new-moon.

An eclipse is called annular; when the moon is so situated, as that its shadow, being less than the disk of the sun, conceals only its centre from our sight; whilst the edge of the sun appears like a bright ring all around it.

A *Lunar Eclipse*, or an eclipse of the moon, is caused by the earth's passing between the sun and the moon; whereby the moon is necessarily darkened, as it is thus deprived of the light of the sun. This can only happen when the moon is in opposition to the sun; that is, at the full-moon. The moon is seldom perfectly dark even in a total eclipse; which is said to be owing to the sun's rays being refracted, or bent inwards, in passing through the atmosphere of the earth.

The reason of the sun not being eclipsed every new-moon, and the moon every time she is full, is, that the moon's orbit is inclined to the plane of the ecliptic: so that an eclipse

can

can never happen, except when the moon is either in or near one of the nodes; which are the two points in which the orbit of the moon cuts the ecliptic.

A lunar eclipse appears the same in all parts of the world where the moon is visible at that time; but a solar eclipse will appear differently in different places.

An eclipse of the moon always begins on her eastern side, and an eclipse of the sun begins on his western side.

The greatest number of eclipses of both luminaries which can happen in a year, is seven; and the least, two; but the most usual number is four; and there are very seldom more than six, one half of which are generally invisible at any particular place.

Astronomers suppose the diameters of the sun and moon to be divided into twelve equal parts, which they call digits; and an eclipse is said to be of so many digits according to the number of those parts which are involved in darkness.

OF

OF the ASTRONOMERS who have been most celebrated, the following are the principal:—

PTOLEMY, an Egyptian; who lived about 130 years before Christ.

COPERNICUS; about the middle of the 16th century.

TYCHO BRAHE, a Dane; the end of the 16th century.

KEPLER, a German; the end of the 16th century.

GALILEO, an Italian; the end of the 16th century.

DES-CARTES, a Frenchman; about the middle of the 17th century.

Sir ISAAC NEWTON, an Englishman; the end of the 17th century.

THE TELESCOPE is said to have been originally invented by Roger Bacon in the 13th century;

century; but the invention having been neglected or forgotten, was renewed by Galileo, to whom the idea was suggested by Zachariah Jansen, a spectacle-maker of Middleburgh in Holland; his children having accidentally discovered the effect produced by glasses placed in such a particular position with regard to each other.

THE TIDES are the flux and reflux of the ocean: which is in continual agitation, ebbing and flowing alternately, without the least intermission. This is chiefly owing to the moon, which, in passing over any particular part of the ocean, attracts and raises the waters in that part; but in the course of about six hours and eleven minutes they fall again; and thus constantly rise and fall once in rather more than twelve hours. The moon produces the effect of raising the water,
both

both upon that part over which she is passing, and upon that which is immediately opposite.

The sun also affects the tides in some degree; and at the time of the new and full-moon, the sun and moon acting together upon the water, elevate it more considerably; and these are called *spring-tides*; but at the moon's first and last quarters, the sun and moon act contrary to each other; the water does not then rise so high; and these are called *neap-tides*.

The effect of the moon upon the water, at any particular place, does not appear till three hours after it has past the meridian of that place.

What has here been said of the regularity of the tides, relates to such places only as lie open to large oceans. In seas and channels, which are more confined, various causes concur to occasion considerable deviations from the general rule.

All rivers which fall into the sea, have a flux and reflux to some distance from their mouth.

YE chief! for whom the whole creation smiles,
 At once the head, the heart, and tongue of all,
 Still sing the God of Seasons, as they roll.

These, as they change, Almighty Father! these,
 Are but the varied God. The rolling year
 Is full of Thee. Forth in the pleasing *spring*
 Thy beauty walks, Thy tenderness and love.
 Wide flush the fields; the softening air is balm;
 Echo the mountains round; the forest smiles;
 And every sense, and every heart is joy.
 Then comes Thy glory in the *summer-months*,
 With light and heat resplendent. Then thy sun
 Shoots full perfection through the swelling year;
 And oft Thy voice in dreadful thunder speaks;
 And oft at dawn, deep noon, or falling eve,
 By brooks and groves, in hollow-whispering gales.
 Thy bounty shines in *autumn* unconfin'd,
 And spreads a common feast for all that lives.
 In *winter* awful Thou! with clouds and storms
 Around Thee thrown, tempest o'er tempest roll'd,
 Majestic darkness! on the whirlwind's wing
 Riding sublime, Thou bid'st the world adore,
 And humblest nature with thy northern blast.

Mysterious round! what skill, what force divine,
 Deep-felt, in these appear! a simple train,

Yet

Yet so delightful mixt, with such kind art,
 Such beauty and beneficence combin'd,
 Shade, unperceiv'd, so softening into shade.
 And all so forming an harmonious whole,
 That, as they still succeed, they ravish still.

But wandering oft, with brute unconscious gaze,
 Man marks not Thee; marks not the mighty hand,
 That, ever busy, wheels the silent spheres;
 Works in the secret deep; shoots, streaming, thence,
 The fair profusion that o'er spreads the spring;
 Flings from the sun direct the flaming day;
 Feeds every creature; hurls the tempest forth;
 And, as on earth this grateful change revolves,
 With transport touches all the springs of life.

THOMSON.

YE headlong torrents! rapid and profound;
 Ye softer floods; that lead the humid maze
 Along the vale; and thou, majestic main!
 A secret world of wonders in thyself,
 Sound His stupendous praise: whose greater voice,
 Or bids you roar, or bids your roarings fall.

THOMSON.

LECTURE

LECTURE V.

*Of GRAVITY, LIGHT, AIR, SOUND,
ELECTRICITY, and MAGNETISM.*

BEHOLD! God is great. Remember that thou magnify his work, which men behold.— Every man may see it, man may behold it afar off.

He hangeth the earth upon nothing.

The pillars of heaven tremble, and are astonished at his reproof.

And God said, Let there be light: and there was light. And God saw the light, that it was good. And God divided the light from the darkness. And God called the light, day; and the darkness he called night. And the evening and the morning were the first day.

THE

THE tendency which all bodies have to descend, is called *the principle of gravitation*; and that point towards which they tend, is called *the centre of gravity*. Thus the Sun is the centre of gravity in the solar system; and the centre of the earth and of every other planet is also a centre of gravity, towards which all bodies, placed upon the surface of the earth or planet, are attracted. If you stand upon a table, you are prevented by that table from falling to the ground; but if you jump off, you immediately descend upon the floor; and if by any accident the floor were to break and give way, you would sink through it: thus if you imagine the earth to open under your feet, as deep as to the centre, you would fall to that point, and remain fixt there, even if there were an opening beyond, which could admit you to pass further.

That

That power by which the planets are attracted towards the sun, as their centre, is called the centripetal force; and that by which they endeavor to fly off from it, is termed the centrifugal force. By the contrary action of these two powers, the planets are made to move round the sun, in a circular, or rather, in an elliptical orbit.



VARIOUS opinions have been entertained concerning the nature of LIGHT; but it is now certainly known to be a material substance, flowing directly from the sun. Therefore from the time of the sun's rising to that of his setting, we, being enlightened by his rays, have day: and from his setting to his rising again, we have night.

Though the fixed stars are believed to be luminous bodies of the same nature as the sun, yet on account of their immense distance from the earth, the light we receive from them

them, even in the brightest star-light night, is but very faint.

The rays of light move at the rate of almost twelve millions of miles in an hour : a rapidity too great for our imagination to follow.

THE earth is surrounded by a body of air called the *atmosphere*, through which the sun's rays fall upon the earth ; but in passing through it, they do not move in straight lines, except when the sun is in the zenith ; (that is, directly over our heads) but when they reach our atmosphere, they bend downwards ; which is the cause of the twilight ; for the rays of light, pointing upwards from the sun before he rises, and after he has set, bend towards the earth upon reaching the atmosphere ; and by this means it begins to be light in the morning, when the sun arrives at eighteen degrees below the eastern horizon

horizon, and continues to be light in the evening, till he is sunk eighteen degrees below the western. This bending of the rays of light, is called refraction, and is always the consequence of their passing in an oblique or sloping direction from one medium into another; as from water into air, or from air into water. You may exemplify this, by putting a shilling into an empty bason, and placing yourself at such a distance from it, as that the edge of the bason may conceal the shilling from you; if some person then fills the bason with water, you will see the bottom of the bason and the shilling, by means of the refraction occasioned by the water.

SOUND is produced by an agitation of the air, arising from the tremulous motion of the parts of any sonorous body when struck upon; which, by causing the air around it

it to vibrate to a certain distance, conveys the sound to the ear which may be within reach of that vibration.

Sound moves at the rate of 68,520 feet in a minute, or 1142 feet in a second or moment.

ELECTRICITY is that property of particular bodies, whereby, after having been rubbed, and by that means heated to a certain degree, they acquire a power of attracting and repelling other bodies; and frequently of emitting sparks and streams of light.

All bodies which contain within themselves the quality of electricity, and need only to be rubbed to excite it, are called originally electrics; and all those which do not possess this property, and can acquire that quality only by communication with electrified bodies, are called non-electrics.

MAGNETISM

MAGNETISM is another wonderful phænomenon. The *magnet* or *loadstone* is a mineral, which has the property of attracting and repelling iron. If you place a piece of iron near one end of a magnet, it will immediately move forward till it touches it; and if you then lift up the magnet, the iron will appear to be fastened to it, and will remain so, till you remove it by force. But every magnet has what are called its north and south poles; one of which will repel, or drive back, the same piece of iron which the other will attract.

The *Mariner's Compass*, which is frequently mentioned in the accounts of voyages, is an instrument used at sea. This instrument is circular, and has a kind of dial-plate divided into thirty-two equal parts by right lines drawn from the centre to the circumference: these thirty-two points are called *the points of the compass*; and the four principal ones, viz. east, west, north, and south, are denominated *the cardinal points*. Over this dial-plate is suspended a thin piece of iron,

which, by being touched by a magnet or loadstone, acquires a magnetic virtue, whereby its two poles are made to point nearly to the north and south poles of the world. This is called the magnetic needle ; and it is of the greatest use in determining the course of ships, and the variation of the winds.

Maps have generally a compass drawn upon them, in which the north is distinguished by a fleur-de-lys.

LET there be light, said God: and forthwith light
Sprung from the deep. God saw the light was good;
And light from darkness by the hemisphere
Divided: light the day, and darkness night
He nam'd. Thus was the first day ev'n and morn:
Nor pass'd uncelebrated, nor unsung
By the celestial quires, when orient light
Exhaling first from darkness they beheld;
Birthday of heaven and earth: with joy and shout
The hollow universal orb they fill'd,
And touch'd their golden harps, and hymning prais'd
God and his works: Creator him they sung,
Both when first evening was, and when first morn.

MILTON.

LECTURE VI.

Of METEORS, and the RAINBOW.

CANST thou lift up thy voice to the clouds,
that abundance of waters may cover thee?

Hast thou entered into the treasures of the
snow: or hast thou seen the treasures of the hail?

Canst thou send lightnings that they may go,
and say unto thee, here we are?

The LORD thundered in the heavens, and the
Highest gave his voice. His lightnings enlight-
ened the world.

Sing unto the LORD with thanksgiving; sing
praises unto our God: who covereth the heaven
with clouds; who prepareth rain for the earth.

By his knowledge the clouds drop down the dew.

He causeth the vapours to ascend from the ends
of the earth.

He bringeth the winds out of his treasures.

Great things doth he, which we cannot com-
prehend. For he saith to the snow, be thou on

the earth. By the breath of God, frost is given: the face of the deep is frozen. He sendeth out his word, and melteth them: he causeth his wind to blow, and the waters flow.

And God said, I do set my bow in the cloud; and it shall be for a token of a covenant between me and the earth. And I will remember my covenant which is between me and you, and every living creature of all flesh; and the waters shall no more become a flood to destroy all flesh.

Look upon the rainbow, and praise him that made it: very beautiful it is in the brightness thereof. It compasseth the heaven about with a glorious circle, and the hands of the Most High have bended it.

METEORS are of three kinds; fiery, airy, and watery.

Fiery meteors consist of vapours set on fire: such are, lightning, falling stars, and other phœnomena appearing in the air.

Airy

Airy meteors, as winds, tornados, &c. are caused by the unequal temperature of the air, arising from the action of heat and cold.

Watery meteors are composed of vapours, or watery particles, variously modified by heat or cold; as clouds, rain, hail, snow, and dew.

THUNDER is occasioned by a sudden kindling of exhalations in the clouds; and *Lightning* is the fire bursting from those clouds. This fire is electrical; and may be attracted by non-electric bodies; such as iron, earth, &c. The lightning is always seen before the thunder is heard, in proportion to the distance of the thunder-cloud, because light travels more swiftly than sound.

Falling Stars are also vapours kindled in the air; sometimes very near the surface of the earth, and sometimes much higher.

It

It has been generally believed, that there frequently arises, in marshes and other moist places, a meteor, in appearance like the flame of a candle; which has been called the *ignis fatuus*, and, vulgarly, *will-with-a-wisp*, or *jack-with-a-lantern*; but the existence of this meteor is at present doubted.

The *aurora borealis*, or *northern light*, is a meteor, or luminous appearance, which sometimes shews itself during the night in the northern part of the heavens. It is almost constantly visible in the regions near the north pole. The cause of the aurora borealis does not appear to be yet ascertained.

WIND is a stream of air, flowing from one place or region to another. There are regular winds in some parts of the torrid zone: those which blow constantly from the same point are called *trade-winds*; and those which

which blow periodically six months one way, and six months the contrary way, are termed *monsoons.*

THE CLOUDS are produced by the heat of the sun, which draws the damps from the earth, and the water from the rivers and seas, in the same manner as the fire draws the moisture from a piece of wet paper or linen, if held near it; and this is called *evaporation.* When these vapours unite in the air, they form clouds, which sometimes disperse again, but when they become heavier than the air, they break through it, and fall in *rain;* which is separated into small drops by the resistance which it meets with from the air in falling.

Hail is the drops of rain congealed into ice. This happens when, in their passage through the inferior region of the air, they meet with nitrous particles; which greatly contribute

contribute to freezing. The magnitude of the-hail-stones is owing to their acquiring a fresh accession of matter in their descent. Hail is most frequent in summer, because at that season greater quantities of nitre are exhaled from the earth, and float in the air.

When the vapours are become considerably condensed, yet not so far as to be converted into water; then, by a great degree of coldness in the upper region of the air, the particles of the condensed vapour are changed into ice: several of these adhering together, compose small fleeces of a white substance, somewhat heavier than the air, and which therefore descend in a slow and gentle manner through it; being subject, by reason of their lightness, to be driven about by the various motion of the winds: and this is what we call *snow*.

Frost is occasioned by excessive cold, which converts water and other fluid liquid matters into ice. The hoar-frost is the dew changed into ice by the cold.

Dew

Dew is a dense moist vapour, falling on the earth in form of a drizzling rain, whilst the sun is below the horizon. In summer, when the weather is fair and very dry, and the surface of the earth has been for a considerable time parched by the heat of the sun; then, not only the watery, but likewise other less volatile particles, as the oily, and the saline, or salt, are, by the power of the sun's beams, raised into the air, and fill that part of it which is the nearest to the surface of the earth. As long as these exhalations are kept in agitation by the heat of the sun, they are invisible; but as soon as the solar heat (which acts with the greatest force about three in the afternoon) begins to remit, there is collected a white dense vapour, which remains till it is dissipated in the morning by the heat of the rising sun.

A *fog* is a meteor consisting of gross vapours floating near the earth's surface. When the air is extremely cold, the vapours cannot ascend through it, but are condensed near
the

the surface of the earth; and either return in dews or drizzling rain, or remain suspended as fogs; which are only clouds formed in the lowest region of the air. Objects viewed through a fog appear magnified.

IN this place may properly be mentioned the *rainbow*, or *iris*. The rainbow is perceived, when a cloud, converted into rain, is exposed to the rays of the sun, and the eye of the spectator is between the sun and the cloud. The colours of the rainbow are, red, orange, yellow green, blue, indigo, and violet. These colours are produced by the refraction of the rays of light, which pass through the rain with which the atmosphere is filled. The uppermost drops of rain reflect the red rays; the next in order are the orange, the yellow, the green, the blue, the indigo, and the lowest are the violet.

The

The sun cannot be more than 42 degrees above the horizon when a rainbow appears, because when it is higher, its axis passes beyond the eye of the spectator.

THE thunder rolls: be hush'd the prostrate world;
While cloud to cloud returns the solemn hymn.

THOMPSON.

HIS praise, ye winds! that from four quarters
blow,
Breathe soft or loud.—

MILTON.

YE mists and exhalations! that now rise
From hill, or steaming lake, dusky or grey,
Till the sun paint your fleecy skirts with gold,
In honour to the world's great Author, rise.
Whether to deck with clouds th' uncolour'd sky,
Or wet the thirsty earth with falling showers,
Rising, or falling, still advance his praise.

MILTON.

— IN the cloud a bow,
Betokening peace from God, and covenant new.
So willingly doth God remit his ire,
That he relents,
And makes a covenant never to destroy
The earth again by flood, nor let the sea
Surpass his bounds, nor rain to drown the world,
With man therein, or beast; but when he brings
Over the earth a cloud, will therein set
His triple-colour'd bow, whereon to look,
And call to mind his covenant.

MILTON.



LECTURE

LECTURE VII.

*On the Connection of RELIGION with
the STUDY of NATURE.*

WHEN you glorify the LORD, exalt him as much as you can, for even yet will he far exceed; and when you exalt him, put forth all your strength, and be not weary, for you can never go far enough.

The glory of the LORD shall endure for ever: the LORD shall rejoice in his works.

There are yet hid greater things than these be, for we have seen but a few of his works.

The invisible things of him from the creation of the world are clearly seen, (being understood by the things that are made) even his eternal power and godhead.

Before the mountains were brought forth, or ever the earth and the world were made, Thou art God from everlasting, and world without end,

Of

Of old hast thou laid the foundation of the earth; and the heavens are the work of thy hands. They shall perish, but thou shalt endure: yea, all of them shall wax old like a garment; as a vesture shalt thou change them, and they shall be changed; but thou art the same, and thy years shall have no end.

IN contemplating the wonders of creation, the mind is naturally led to meditate upon the amazing greatness of that Being by whom they were originally formed, and are constantly preserved and governed. His *wisdom*, *power*, and *goodness*, are displayed in all his works, and in all his dealings. *The Lord by wisdom hath founded the earth: by understanding hath he established the heavens.*—*Touching the Almighty, we cannot find him out: he is excellent in power.*—*The Lord is good to all; and his tender mercies are over all his works.*

When

When we look at the stars, and consider that all those which we behold are probably suns like our own, surrounded by planets as large as this earth, which are from their vast distance invisible to us; and when we further reflect, that all these suns and worlds, with all the space they occupy, are as nothing, in comparison of the immensity of the universe which extends beyond them all around, our imagination is lost in the astonishing idea.

For wonderful indeed are all his works,
 Pleasant to know, and worthiest to be all
 Had in remembrance always with delight:
 But what created mind can comprehend
 Their number, or the wisdom infinite
 That brought them forth, but hid their causes deep?

MILTON.

When we consider that God is equally present in every place, not confined by space, nor limited by time;—that *one day is with the Lord as a thousand years, and a thousand years as one day*;—that *the darkness is no darkness with him; but the night is as clear as the*

days

day; the darkness and light to him are both alike; — with what reverence must we be inspired towards a Being so great! Yet when we behold around us the effects of his goodness, and reflect that without his permission not a sparrow falleth, we shall not only reverence, but love and adore him. Though *thousand thousands* of angels minister unto him, and *ten thousand times ten thousand* stand before him, yet he giveth to the beast his food, and to the young ravens which cry. Though he guides innumerable worlds, and countless systems are subject to his laws; yet he compasseth our path, and is acquainted with all our ways.

The variety of pleasure which the continual vicissitudes of nature are calculated to afford us, is an evident proof of the kindness of Providence towards his creatures: every day, every hour, brings with it some gratification to the mind which is prepared to enjoy it.

SWEET is the breath of morn, her rising sweet,
With charm of earliest birds: pleasant the fun,
When first on this delightful land he spreads
His orient beams, on herb, tree, fruit, and flower,
Glittering with dew: fragrant the fertile earth
After soft showers: and sweet the coming on
Of grateful evening mild: then silent night,
With this her solemn bird, and this fair moon,
And these the gems of heaven, her starry train.

MILTON.

There is no object more sublime or beautiful than the sky in a fine evening, when so many brilliant stars adorn the azure expanse, and the moon appears to move majestically through the midst of them. The evening, with its glorious scenery, has been frequently celebrated by the poets; and has been a subject of universal admiration from the earliest ages. Nature seems hushed to repose; and the soft stillness which prevails around peculiarly tends to compose the spirits, and soothe the mind.

NOW came still Evening on, and twilight grey
 Had in her sober livery all things clad.
 Silence accompanied; for beast and bird,
 They to their grassy couch, these to their nests,
 Were flunk: all but the wakeful nightingale:
 She all night long her amorous descant fung;
 Silence was pleas'd. Now glow'd the firmament
 With living saphires: Hesperus, that led
 The starry host, rode brightest; till the moon,
 Rising in clouded majesty, at length
 Apparent queen, unveil'd her peerless light,
 And o'er the dark her silver mantle threw.

MILTON.

But whilst we admire the creation, and rejoice in the blessings by which we are surrounded, we ought to reflect with humility upon our own insignificance, and with the utmost gratitude upon the goodness and condescension of God towards us. The Psalmist, when considering *the heavens, the work of God, the moon and the stars* which he has ordained, imprest with the deepest sense of the paternal love with which he vouchsafes to favor us, (who, in comparison

of

of the immense universe, are but as *a drop of a bucket*, and as *the small dust of the balance*) exclaims, *What is man, that thou art mindful of him! and the son of man, that thou visitest him?*

If we pursue the study of nature with this disposition of mind, it will become to us an inexhaustible source of pleasure; for we shall derive the highest satisfaction from considering *the earth*, as being *full of the goodness of the Lord*, and *the heavens*, as declaring *his glory.*

THE spacious firmament on high,
With all the blue etherial sky,
And spangled heavens, a shining frame,
Their great Original proclaim.

Th' unwearied Sun, from day to day,
Does his Creator's power display;
And publishes to every land
The work of an Almighty hand.

Soon

Soon as the evening shades prevail,
 The Moon takes up the wondrous tale;
 And nightly to the lift'ning earth
 Repeats the story of her birth:

Whilst all the Stars that round her burn,
 And all the Planets in their turn,
 Confirm the tidings as they roll,
 And spread the truth from pole to pole.

What though in solemn silence all
 Move round this dark terrestrial ball!
 What though nor real voice nor sound
 Amid their radiant orbs be found!

In Reason's ear they all rejoice,
 And utter forth a glorious voice;
 For ever singing, as they shine,
 "The Hand that made us is Divine."

F I N I S.



